

**Deepwater Program: Exploration and Research of Northern Gulf of Mexico
Deepwater Natural and Artificial Hard Bottom Habitats with Emphasis on Coral
Communities: Reefs, Rigs and Wrecks**

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LONG-TERM GOALS

A primary goal of this study is to obtain a robust predictive capability for the occurrence of rich cnidarian (primarily scleractinian coral) hard ground communities in the deep Gulf of Mexico (GoM). To achieve this long-term goal, this study will accomplish three interrelated and interdependent objectives.

OBJECTIVES

The objectives of this study are:

- 1) Discover and describe new locations at greater than 300m depth in the GoM with extensive coral community development, particularly including *Lophelia pertusa*.
- 2) Gain a more comprehensive understanding of the fundamental processes that control the occurrence and distribution of *Lophelia* and other extensive coral communities at depths greater than 300 m in the GoM through both laboratory experiments and field data collection.
- 3) Document and understand the relations between coral communities on artificial and natural substrates with respect to community composition and function, phylogeographic and population genetics, and growth rates of the key cnidarian foundation fauna.

Our specific biological objectives:

- 1) To discover and characterize new sites:
 - a. Characterize key sites at the largest scale with high resolution bathymetry, side scan sonar imaging, 3D seismic data, and current models
 - b. Characterize the coral density at all study sites at the 10 to 100 m scale with randomized photo transects and general site descriptions.
 - c. Characterize the community composition at the 1 to 10 m scale at significant coral sites (man-made and natural) with analysis of close up imagery, replicate 5x5m photomosaics, and quantitative community collections.
- 2) Analyze connectivity among all sites in the GoM (man-made and natural), and to other sampled populations, with comparative community, phylogeographic and population genetic analyses.
- 3) Compare the structure, species richness and diversity of communities tightly associated with *Lophelia* on man-made structures and from natural sites in the GoM
- 4) Experimentally determine the tolerance and growth response of *Lophelia* to temperature, pH/alkalinity, dissolved oxygen and electrical current.
- 5) Characterize and constrain growth rates of key species of colonial cnidarians (pioneer colonies) using analyses of images of the largest colonies on man-made structures of known age.
- 6) Characterize key variables at sites with the most significant communities of coral colony development over one year by monitoring temperature, currents, larval seasonal distribution and sediment quality and quantity at 2-4 sites between 2009 and 2010.

By integrating this information, we will develop a predictive model to examine the potential occurrence of significant assemblages of *L. pertusa* or other cnidarians at unexplored sites and artificial reefs in the deep GoM.

Historic Shipwreck Component

The proposed study will be multidisciplinary in scope. It will focus on the archaeological and biological aspects of up to six shipwrecks in the north-central portion of the GoM. Water depths at the designated investigation sites range from 554m to 2,286m. Each shipwreck will be investigated to

determine identity, site boundaries, National Register eligibility, preservation state and stability, associated biological communities, and an artificial reef effect on meiofauna and/or mobile fish communities.

Our specific archaeological objectives:

- 1) To record each vessel through detailed imagery to establish its type, date of construction, and positive identification if possible.
- 2) To establish nationality, ownership (past and present), use history, cause of loss, mission and cargo at time of loss through fieldwork and historical research.
- 3) To determine the extent and condition of the artifact assemblage on each vessel and the presence of diagnostic artifacts.
- 4) To determine potential eligibility to the National Register of Historic Places through archival research and the analysis of imagery and to prepare a National Register nomination form for potentially eligible vessels.
- 5) To assess impacts of biofouling communities to these shipwrecks to determine the stability of these sites and rate of deterioration.

Our specific bacteriological objectives:

- 1) Determine the rates of deterioration of test coupons placed on platforms and sited on specific shipwrecks that have already been visited and were installed on previous expeditions to those sites of interest. Determination may take the form of passive observations of the coupon condition within the platform of interest. If significant deterioration rates have already occurred then the platform may be recovered for on-ship and in-laboratory investigations.
- 2) Fresh test platforms may be deployed to either replace recovered platforms or to determination the deterioration rate at a fresh site of archeological significance.
- 3) Examine recovered natural samples from deteriorating sites and localized waters that may contain active bacterial communities traditionally associated with corrosive or bio-concretious growths.
- 4) On selected recovered test coupons conduct such experiments as would allow a more precise projection of the rates of deterioration of test material through the rates of pitting (in the event of mild steel) to losses in physical composition (in the event of cloths and wood).
- 5) Recovered bacteriological communities from the sites of interest will be subjected to laboratory analysis to determine major bacterial communities, degrees of activity (using the ATP methodology), and identification of community structures by fatty acid methyl ester analysis (MIDI/BART technologies).

APPROACH AND WORK PLAN

In order to meet the objectives outlined above, the following scientific and technical plan is being implemented.

Key individuals participating in this work and their roles are: Dr. James Brooks is the Project Manager and takes the lead in administration of this project. Dr. Charles Fisher (Pennsylvania State University)

coordinates the biological studies, Dr. Harry Roberts (Louisiana State University) coordinates the geological/geophysical and oceanographic studies, Mr. Dan Warren and Mr. Rob Church from C&C Technology coordinate the wrecks studies along with, Dr. Chris German (WHOI) who coordinates the time series sediment trap studies, and Ms. Liz Goehring (Penn State and NSF Ridge 2000 office) coordinates the education and outreach activities.

Dr. Charles Fisher oversees the biological aspects of the study and the interface with the USGS teams and the geological and oceanographic measurements and studies. He works closely with Dr. Roberts, Dr. Cordes, Dr. German, and other PIs to plan and conduct the submersible/ROV portions of the field work. His research group will take responsibility for quantitative physical and photographic collections, community composition and structure analyses, and trophic studies of the endemic and other closely associated seep and coral fauna. Dr. Harry Roberts, takes the lead in site selection for exploration of potential new natural deep coral communities and also coordinates the geological and oceanographic deployments and studies. His colleague, Dr. Susan Welsh develops and runs a very high resolution numerical circulation model of the Gulf of Mexico that will be used to help identify the likely geographic areas and depth ranges for recruitment of *L. pertusa* larvae on the northern slope and compute dispersal kernel trajectories and dispersion of coral larvae by oceanographic current. Dr. Erik Cordes takes responsibility for the live *Lophelia pertusa* experiments, gorgonian genetics, and coordinate the phylogeography and taxonomy team. He also works with Fisher's team on studies of coral communities and is responsible for coordination with other outside taxonomic experts. Dr. Ian MacDonald directs the use of digital imagery in the initial site survey and recon cruise, and deployment and analyses of the time lapse cameras and imagery. Dr. Chris German takes the lead on deployments of the time series sediment traps and oversee the integrated analyses of the samples. Dr. William Schroeder assists in the analysis of coral communities on rigs and wrecks and also participates in the over-all study synthesis phase. Dr. Tim Shank conducts studies on the population genetics of several coral associated taxa. Dr. Iliana Baums oversees development of molecular markers for studies of population connectivity in antipatharians and also serve as consultant for the construction of live *Lophelia* maintenance aquaria. Dr. Stephen Cairns is responsible for the identification of the hard coral samples collected. Peter Etnoyer oversees the classical taxonomy of octocorals and Dr. Dennis Opresco the classical taxonomy and phylogeography of antipatharians.

In addition to this core team we have assembled an international team of collaborators that significantly expands our taxonomic expertise. Limpets and snails are sent to Anders Waren (Swedish Museum of Natural History) for morphological characterization. Dr. Stéphane Hourdez (Station Biologique de Roscoff, France) takes the lead on polychaete phylogenetic characterizations and descriptions of new species (using both molecular and classical approaches). Dr. Daphne Fautin (University of Kansas) assists in the taxonomic identification of sea anemones Dr. Sabine Stohr (Swedish Museum of Natural History) examines all new ophiuroids collected. Maria Pia Miglietta (Penn State University) leads the morphological and genetic identification of the hydrozoans.

C & C Technologies, Inc. (C & C) of Lafayette, LA has partnered with Droycon Bioconcepts Inc. (DBI) of Regina Canada to fulfill the archaeological component of the study. Marine archaeologists Daniel Warren and Robert Church are the C & C project managers and co-principle investigators. Dr. Sheli Smith is the director of operations for the PAST Foundation, a subcontractor to C & C. She has substantial knowledge in eighteenth and nineteenth century marine architecture and is assessing three to four of the wreck sites in this study from those periods.

Dr. Roy Cullimore, the CEO of DBI, and Lori Johnston primary role on this project is to evaluate the deterioration rate, preservation, and stability of the wreck sites. Re-examining test platforms placed during the earlier studies will be instrumental to this analysis. They coordinate with Dr. Christina A. Kellogg with USGS for other microbiology aspects during the project.

Dr. Bernie Bernard, TDI-Brooks Director and Chief Technology Officer, coordinates the navigation and logistics portion of the project. Dr. Gary Wolff is the project's Data Manager as he has been for other BOEM projects including the Chemosynthesis-series. Ms. Suzanne Cardwell provides financial and project administrative support.

WORK COMPLETED

Four cruises have been completed since Lophelia II began. **Table 1** summarizes the dates, ships used and objectives.

Cruise	Dates	Ship	Comments
1	2 September - 2 October 2008	<i>Nancy Foster</i> - NOAA	Ewing Banks Wreck, <i>Gulfoil</i> , <i>Gulfpenn</i> sites studied
2	16 June - 1 July 2009	<i>RV Brooks McCall</i> – TDI-Brooks	multibeam collected at 13 sites and ROV at 8 sites
3	19 August - 12 September 2009	<i>Ron Brown</i> - NOAA	multibeam swath bathymetry, digital video and photographs
4	13 October - 4 November, 2010	<i>Ron Brown</i> - NOAA	17 ROV dives including the Macondo well area

RESULTS

Cruise1 Leg1 – Using NOAA Ship *Nancy Foster* / *SeaVision* ROV, the Ewing Banks Wreck site was confirmed to be a historic shipwreck site, which likely dates to the nineteenth century. More *Lophelia* was discovered growing on that site than any other nineteenth century wooden wreck known in the Gulf of Mexico. Many of the wreck's attributes, such as the lack of cargo, rigging, or machinery, make it an intriguing mystery. The identity of *Gulfoil* was confirmed on a brief dive at the site and substantial coral colonies were documented. The preliminary examination suggests the *Lophelia* coverage at *Gulfoil* may be more substantial than that documented at *Gulfpenn* in 2004. The dive on *Gulfpenn* allowed the identification of the stern section of the tanker, the microbial experiment placed on the site in 2004 was reexamined, and a temperature logger was placed on *Gulfpenn*'s bow.

Cruise1 Leg2 - During the 12 working days at sea, multibeam data was collected at 13 sites and 10 lowerings of the ROV were completed over 8 different sites. There were two ROV operations days lost to weather conditions, one dive never reached the bottom, and three other dives were ended with under two hours of bottom time due to technical problems with the ROV. During almost every dive the manipulator failed, and this severely limited the capacity to collect physical samples for future genetics work. On most of the latter dives, only one attempt was made to collect samples in areas of high coral diversity and density due to the anticipation of manipulator failure and the extremely long amount of time required to sample (1-5 samples obtained in 1-3 hours).

Cruise 2 - The cruise team was at sea for 15 days on board the *RV Brooks McCall* and transited from Freeport, TX to the Garden Banks Lease Area south of the Flower Garden Banks and then to the Green

Canyon lease area. The primary data collected includes multibeam swath bathymetry, digital video and still photographic imagery, and CTD with DO and pH sensors. Other data streams from the AUV, such as vehicle attitude, acoustic data, and sonar imagery are recorded by networked computers in the control van. Navigational data for both the ship and AUV systems will also be recorded. While in transit to and from the site, and during times when the AUV is not deployed, photographic data will be collected with the camera sled.

Cruise 3 - *Jason II* was used to: explore 10 new sites for the occurrence of deep water coral reefs; make collections of *Lophelia* and other corals for genetic and physiological studies, make collections of communities associated with *Lophelia* and other corals for ecological studies; collect quantitative digital imagery for characterization of sites and coral communities; collect spatially explicit physical near bottom oceanographic data; deploy cameras and microbial arrays; reposition larval traps and current meters; collect push cores; and conduct a series of linked archeological/ biological investigations on deep water shipwrecks. In addition to launching and recovering *Jason II*, elevators were deployed and recovered twice, four moorings (2 larval traps and 2 current meters) were deployed, and CTD casts were conducted. 19 August – 12 September 2009

Cruise 4 - The cruise was completed on NOAA Ship *Ronald H. Brown* from 13 October – 4 November 2010. The cruise mobilized in Pensacola, Florida. One mid-cruise personnel transfer took place on 24 October. The cruise demobilized in Pensacola, Florida on 5 November 2010. This was a 22-day cruise with 17 ROV dives including the Macondo well area.

IMPACT AND APPLICATIONS

National Security

This program will provide critical information on the exploration, characterization and function of hardground communities to BOEM. As manager of the nation's seafloor mineral resources, BOEM will use this information to aid in the development of critical energy resources, which may affect domestic energy production.

Economic Development

Increased energy and mineral production will have a positive economic impact at numerous levels in industry.

Quality of Life

Information on the location and functioning of hardground communities gathered by this program will have a positive impact on other ocean users, the natural environment, and the human environment. It will aid in minimizing the environmental impact on sensitive habitat and mitigate any potential damage to these communities.

Science Education and Communication

Education outreach efforts outside of the cruise website build on and leverage from the success of both the NOAA OE educational materials and the existing FLEXE (From Local to Extreme Environments) educational project. Full instructional units have been developed on deep-sea coral ecology integrated with the NOAA/OE lessons, multimedia modules and Ocean Explorer website featured as the GLOBE FLEXE campaign for the 2010-2011 academic years.

TRANSITIONS

Data is provided to the ChEss database, which is a component of the Census of Marine Life (CoML) Ocean Biogeographic Information System (OBIS) data base. This work will contribute significantly to the goals of the Atlantic Equatorial Belt studies of the ChEss program, particularly the components that will allow interpretation of our findings in the context of hardground habitats around the world.

RELATED PROJECTS

- Chemosynthetic Ecosystems Study (MMS Report 95-0021).
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- Stability and Change in Gulf of Mexico Chemosynthetic Communities (MMS Report 2002-036). <http://www.gomr.mms.gov/homepg/regulate/environ/studies/2002-036.pdf>.
- The Deepwater Program: Northern Gulf of Mexico Continental Slope Habitat and Benthic Ecology (MMS contract 1435-01-99-CT-30991).
- Investigations of Chemosynthetic Communities on the Lower Continental Slope of the Gulf of Mexico. (Award Number: 1435-01-05-39187) <http://tdi-bi.com/chemo3/chemo-main.htm>

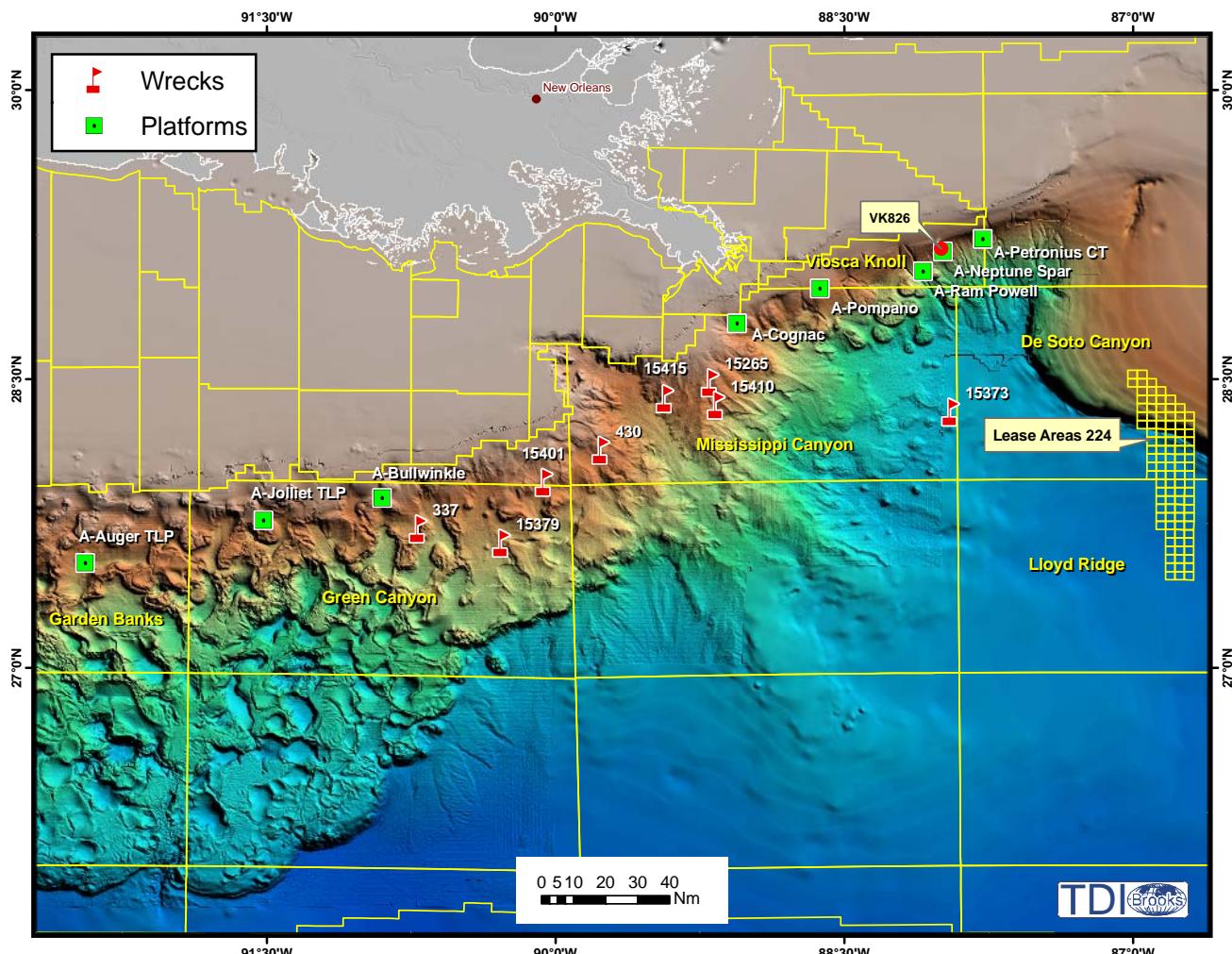


Figure 1. The northern Gulf of Mexico sites and study area

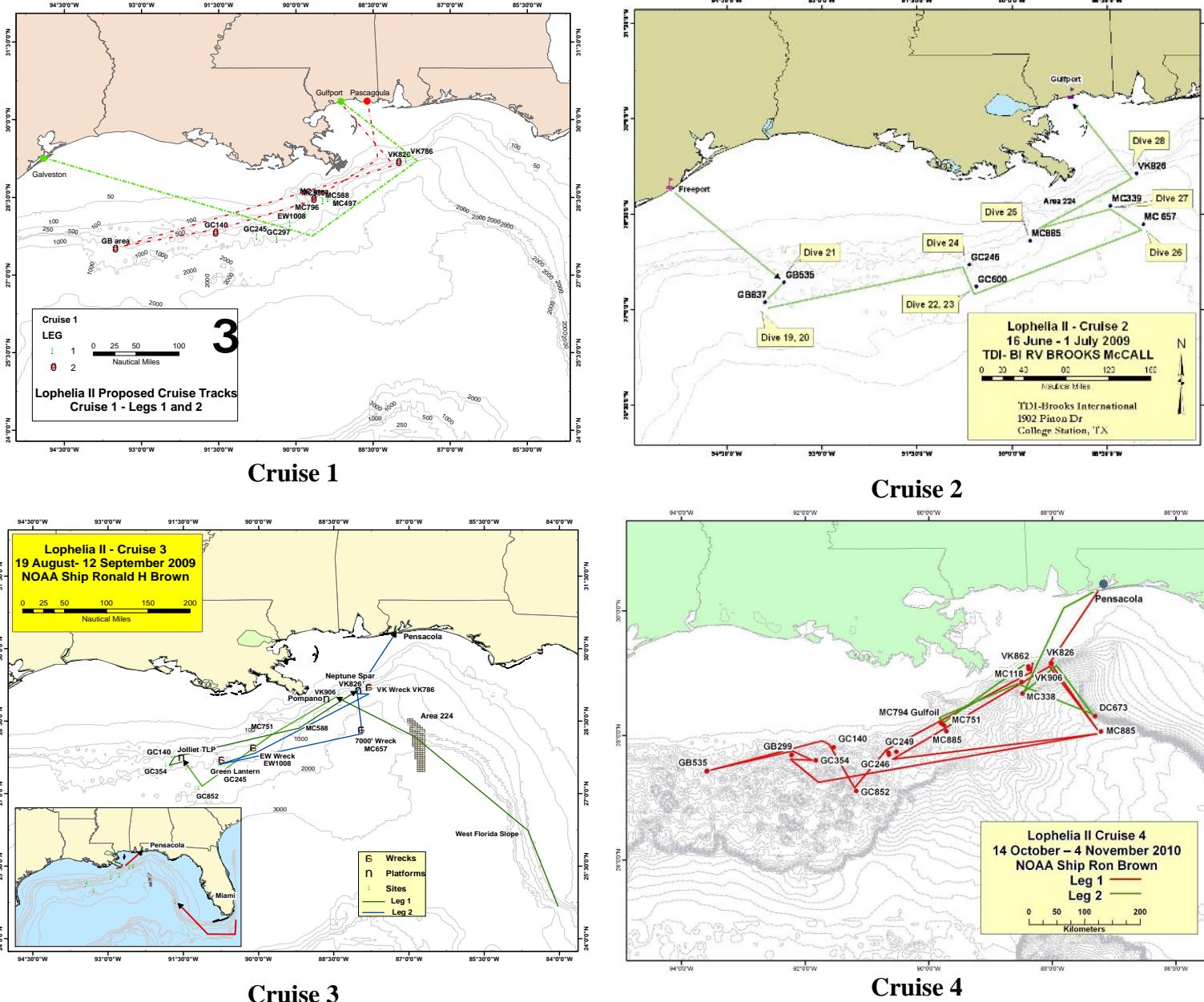


Figure 2. Station locations of the project's four cruises.

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